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WASTE DISPOSAL AT A STEEL PLANT: TREATMENT OF SEWAGE

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WASTE DISPOSAL AT A STEEL PLANT: TREATMENT OF SEWAGE

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INTRODUCTION

The construction of the Fairless Works Sewage Treatment Plant was completed about December 1952 and sewer connections to the plant were completed early in 1953. The treatment plant has been in operation since the spring of 1953. The Fairless Works is served by a system of separate sewers and only the flow from sanitary sewers reaches the sewage treatment works. The sanitary sewage comprises wastes from toilets, wash rooms and showers. The effluent from the plant is discharged into the Delaware River in the vicinity of Morrisville, Pennsylvania.

Requirements of Design

The requirements for effluents discharged into the Delaware are that practically all suspended material and 85% of biochemical oxygen demand be removed from the raw sewage. Accordingly, complete treatment is required. It was further required that the plant be designed for maximum simplicity of operation but that all possible means be employed to maintain U. S. Steel's good neighbor policy. Experience with installations at other steel mills and industrial installations together with circumstances surrounding this particular case, indicated that the following problems had to be met:

a) The possibility of low or zero flows during holiday or other shut down periods requiring provisions for maintaining activity of biological processes.
b) Wide and sudden flow and quality variations requiring facilities capable of absorbing these shocks.
c) Essentially weak character of raw sewage - about one third of the strength of normal municipal domestic sewage.

From the standpoint of design and construction, the site available for the plant was on a flood plain of the Delaware requiring some 20 feet of fill to bring the ground level up to the general grade of the rest of the plant site and above maximum river flood level. Thus, the treatment plant structures were subject to hydrostatic uplift and required piling. The variation in river levels at this location is about 14 feet between low water and design flood level.

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Design Population and Sewage Flows

Population provided for is shown in Table I.

Table I

Population Data - Fairless Works - Sewage Treatment Plant

Initial Population	7,000 people
Immediate Construction - Design Basis	9,000
Immediate Construction - Day Shift	5,040
Swing Shift	1,980
Night Shift	1,980

When present projected mill facilities are in full swing, it is estimated that 7,000 people would be tributary to the plant. Accordingly, a basis of design of 9,000 persons was adopted for initial treatment plant construction. It was also estimated that mill operations would be such that 56% of population served would contribute sewage during the day shift hours and the remainder of persons employed would be equally divided between swing shift and night shift.

Design Flows

The flow pattern was based on flow measurements at other steel mills and industrial installations and in general involves sustained high flows during day shift hours with major peaks at shift change times of 8 A.M. and 4 P.M. and minor peak at noon. Sewage flows used as design basis are shown in Table II.

Table II

DESIGN FLOWS
FAIRLESS WORKS
SEWAGE TREATMENT PLANT

Total Average Daily Flow at 60 gal/cap/day	540,000 G.P.D.
Allowance for Infiltration	50,000
Day Shift Average Rate	957,200
Shift Change Max. Rate (225% of day shift average)	2,045,200
Max. Hot Summer Day Rate (500% of daily average)	2,700,000

The plant was designed for an average flow equal to average day shift rate and was made hydraulically capable of passing maximum rate of 2.7 m.g.d. The sewage plant hydraulics had to be accommodated to the wide flow variations expected.

Sewage Quality

Sewage quality anticipated, and based upon sampling at other steel mills and industrial installations, comprises a fresh sewage with low

concentration of suspended matter and B O D, high in dissolved oxygen, alkaline and with high percentage of volatile solids. Design was based upon 0.06 lbs. per capita for both suspended solids and B O D (approx. 1/3 of strength of domestic municipal sewage.) Operation of plant to date indicates values of one half of these amounts but an accurate determination has not been possible since there is still construction in progress at the mill site and mill operations have not yet reached normal circumstances.

General Description of Treatment Plant

Flow diagram of treatment is shown in Figure 1. Site Plan is shown in Figure 2. Hydraulic profile is shown in Figure 3.

The influent sewer reaches the plant at low level elevation plus 2.00. After comminution the sewage is pumped to a two story "Clarigester" with settling in the upper compartment and digestion in the lower compartment. Flow through the treatment plant, thereafter, is by gravity. A river flood stage of elevation plus 12 was chosen for design.

The settled sewage flows to the dosing chamber which doses the standard rate trickling filters which operate in parallel. Filter effluent flows to the humus tank and thence to chlorine contact chamber, effluent meter and outfall sewer. Filter humus is discharged by gravity back to the pumping station wet well and resettled in the primary tank. The underflow of the secondary tank is recirculated continuously to remove sludge and recirculation is increased during low flow periods at night and during holidays. Digested sludge flows by gravity from the clarigester digestion compartment to sludge drying beds. The control building shown in Figure 1 is a central control building housing laboratory and electrical controls for water supply, sewage and industrial wastes treatment facilities located at the river site area of the plant. Sewage pumping station wet well level is recorded in the central control building and a high water alarm is provided. The sewage measuring flume is provided with indicating and recording meter in the central control building. Red and green indicating lights for sewage pumps are also provided on central control panel in this building.

Plant Facilities

Two comminutors are installed in the comminutor chamber above the pumping station wet well. Each comminutor has a normal capacity of 1 m.g.d. and is capable of handling peak flows up to 2.7 m.g.d. Thus, the two units installed are standby for each other for the present operations. By-pass bar screen is provided for comminutors.

The pumping station wet well provides 10 minutes detention at average day shift rate. Pumps operate automatically by float switch settings.

Primary Tank

Primary Tank is shown in Figure 4.

The primary tank is a 40 foot diameter two story tank with mechanical scraping and skimming in the settling compartment and mechanical mixing in the digestion compartment.

The settling compartment has 11 ft. side water depth providing a capacity of 103,500 gallons. This capacity provides a detention time of 2.6 hours at average day shift design rate of .957 m.g.d. Overflow rate is 764 gallons per day per square foot at design rate of .957 m.g.d.

Digestion compartment is unheated and has a 12 ft. side water depth and provides a digestion capacity of 15,060 cubic feet or 1.67 cubic feet per capita of design population assuming solids content in sewage equal to 1/3 of municipal domestic sewage. Thus, the equivalent of 5 cubic feet per capita for normal domestic sewage is provided.

Primary tank is provided with scum pit containing scum pump and piping arrangement which allows pumping of settling compartment skimmings to digestion compartment and digester supernatant to settling compartment. Recommended operation for scum disposal is for all scum to drain to pump station wet well and be dissipated by recirculation. Initial operation indicates this to be the case. Scum pit, settling compartment and digestion compartment drains are provided. Sludge sampling valve is provided in scum pit. Telescopic valve in scum pit allows digester supernatant removal from digestion compartment.

Trickling Filters and Dosing Tanks

Filters and dosing tank are shown in Figure 5.

Two 75 foot diameter trickling filters with 7 foot stone depth are provided. Each unit to be fed by trapless dosing syphon. Each syphon will operate up to flows of 500 g.p.m. and will go into continuous operation above this flow. Trickling filters are conservatively designed on the basis of applied load of 250 lbs. of B O D per acre foot based on a design population of 9,000 persons. Filters are provided with inspection boxes at each end of filter effluent channels and provision is made for chlorination of filter influent. Filters are covered with concrete domes, 4 inches thick assuring uniform operating temperatures, confinement of odors and flies, and elimination of snow and ice difficulties. Ample vent openings allow air circulation. Either filter and its dosing tank may be taken out of operation by placing stop gate at dosing tank inlet and closing filter effluent shear gate.

Secondary Settling Tank

The secondary settling tank (Figure 6) is mechanically cleaned with provision for skimming. It is 40 feet in diameter with seven foot side water depth having a settling capacity of 65,600 gallons. Detention time is 1.6 hours at average day shift rate. Telescopic overflow in scum pit permits sludge withdrawal and underflow recirculation. Scum falls into scum pit and flows to wet well by gravity.

The secondary tank drains to the wet well.

Chlorination Facilities

Two chlorinators, each with a maximum capacity of 400 lbs. per 24 hours are located in the chlorinator building. Two points of chlorine application are provided: (a) Chlorine contact tank inlet and (b) trickling

filter influent. Distributor manifold is valved so that chlorine solution from either machine may be directed to either point of application.

Chlorine contact chamber is 30 feet long by 10 feet wide with 5 ft. 8 inches water depth allowing 20 minutes detention at average day shift rate. Provision is made for draining secondary tank back to wet well.

Sludge Drying Beds

Four covered sludge drying beds each with 600 square feet area or a total of 2400 square feet are installed. It is anticipated that 8 dryings per year will be obtained with beds dosed to 9 inches depth.

Digested sludge will flow by gravity to the drying beds. Each of the four beds has a sludge feed valve. In the event of sludge line clogging, provision is made in the sludge bed enclosure to enable connecting a portable mud hog type pump to be connected to the sludge piping for either suction or blow back.

Dried sludge will be shoveled into traveling monorail bucket and loaded onto trucks.

Filtrate from sludge beds flows by gravity to the pumping station wet well.

Measuring Flume and Outfall Sewer

A 24 inch Nozzle is provided for measuring effluent flows.

Indicating, recording and totalizing instrument is located in the central control building.

Outfall sewer is 24 inch diameter cast iron and discharges below low water in drainage canal adjacent to the river.

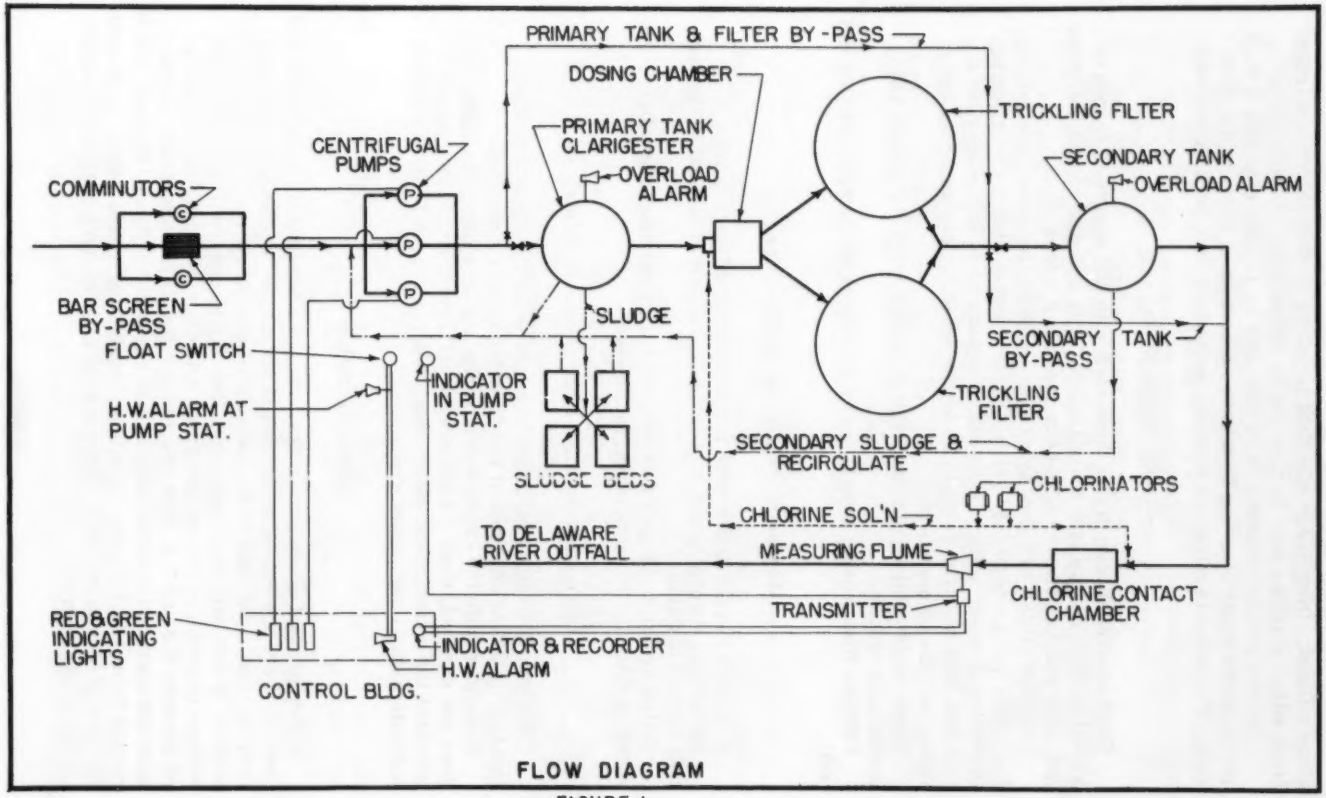
Laboratory Facilities and Operator Safety

Complete laboratory facilities are located in the central control building including services of full time laboratory personnel.

In keeping with the safety rules prevailing throughout the plant, ladders are encaged, stair treads are non-slip type, ample ventilation is provided for underground structures, tanks at ground level are fenced and safety signs are posted throughout.

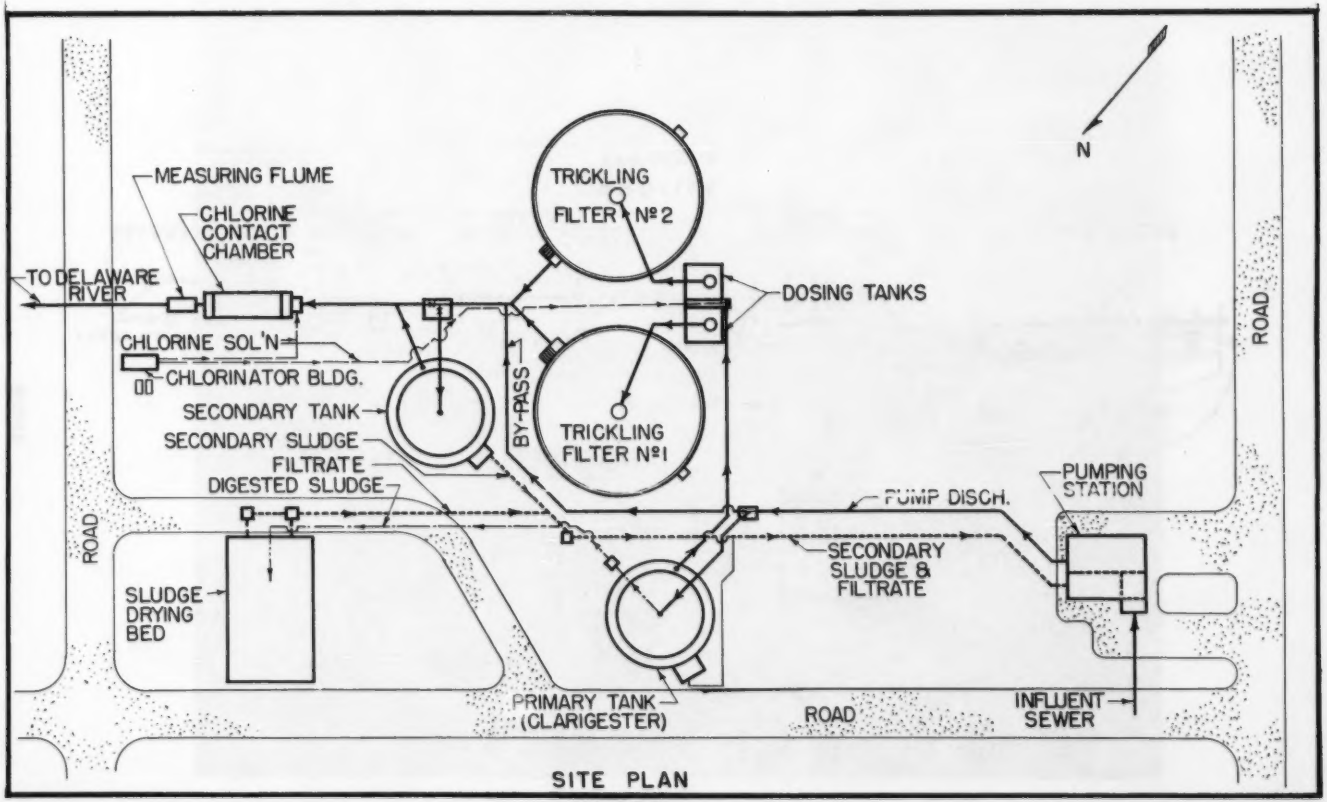
Initial Operation

Under present conditions of operation, the population connected to the plant is about one half of design value and cannot be checked with accuracy in view of the continued presence of considerable construction personnel. It has only been necessary thus far to use one filter. The raw sewage is fresh, is almost saturated with dissolved oxygen, and has a pH between 6.8 and 7.2. The raw sewage B O D and suspended solids have not exceeded concentrations of 50 parts per million. Effluent B O D ranges from 4 to 8.5 ppm and effluent suspended solids from 5 to 22 ppm. Effluent is high in nitrates. Very few filter flies have been noted inside the filter enclosures.



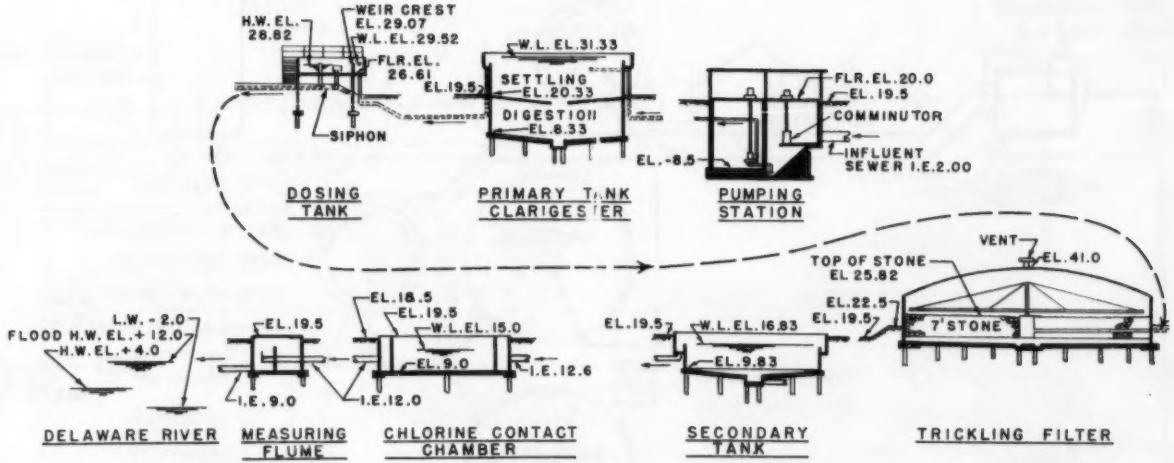
FLOW DIAGRAM

FIGURE 1



SITE PLAN

FIGURE 2



PROFILE

FIGURE 3

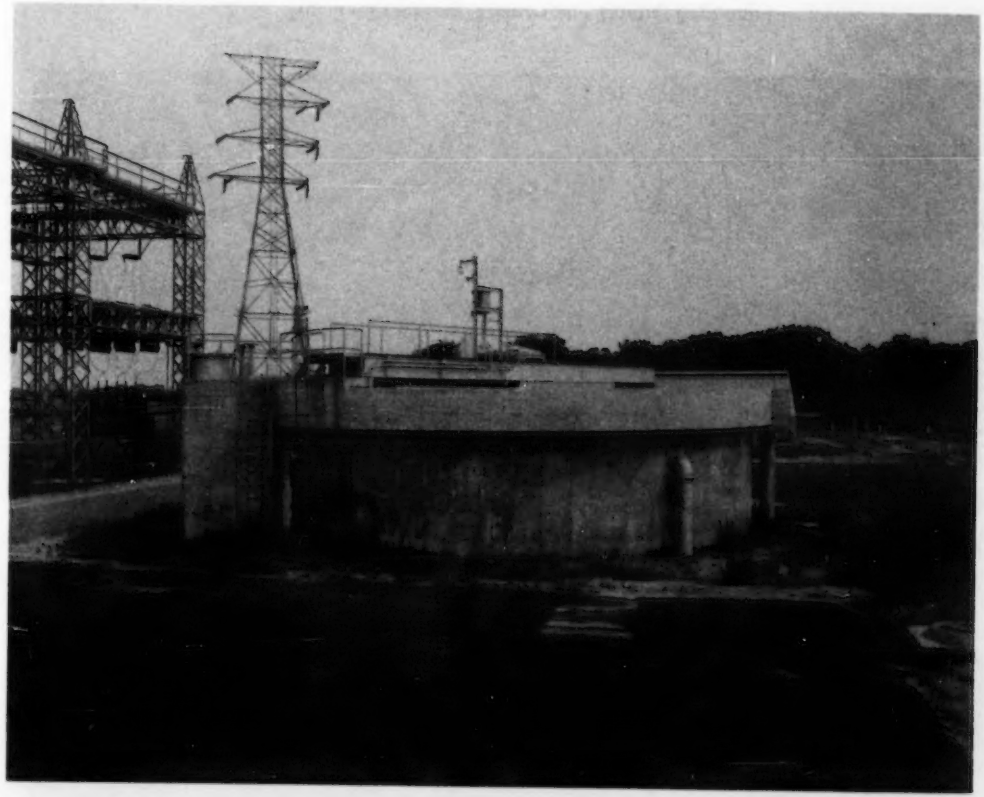


Fig. 4—Primary Tank

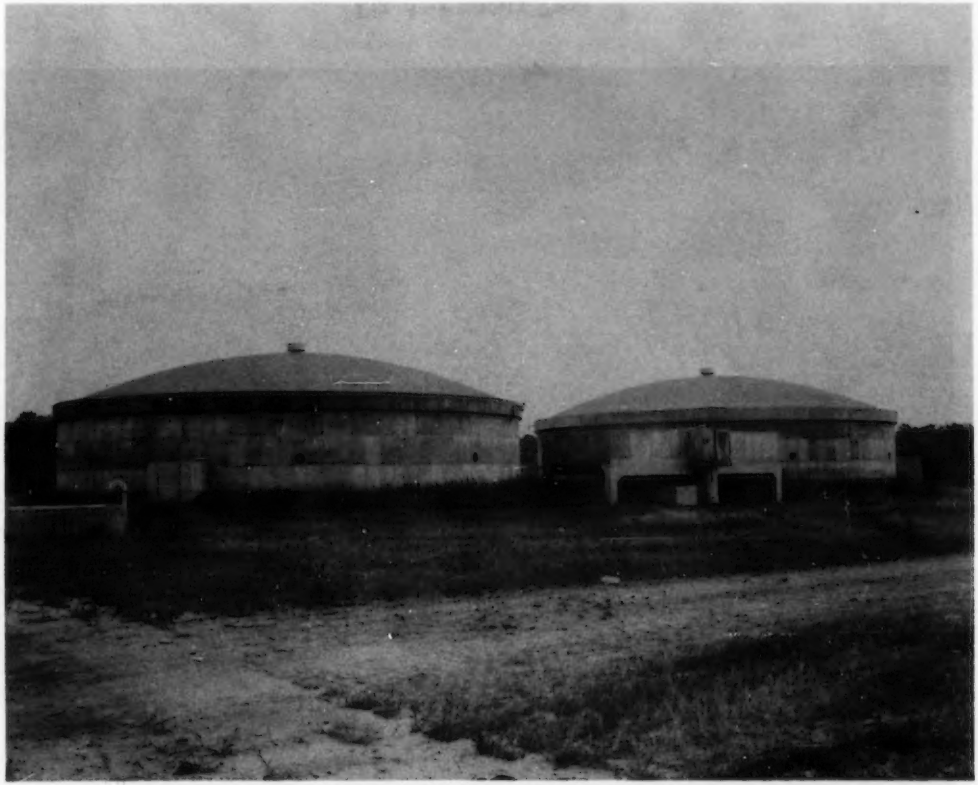


Fig. 5—Trickling Filters and Dosing Syphons

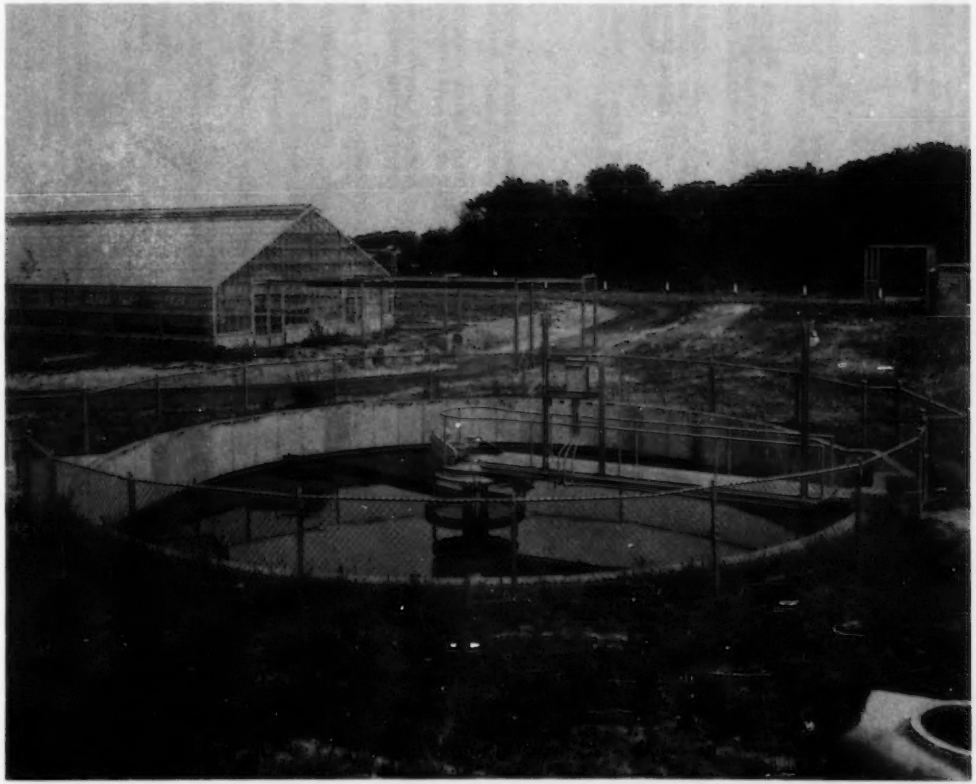


Fig. 6—Secondary Tank - Covered Sludge Beds and Chlorination Facilities in Background

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The technical papers published in the past year are presented below. Technical-division sponsorship is indicated by an abbreviation at the end of each Separate Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways (WW) divisions. For titles and order coupons, refer to the appropriate issue of "Civil Engineering" or write for a cumulative price list.

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SEPTEMBER: 260(AT), 261(EM), 262(SM), 263(ST), 264(WW), 265(ST), 266(ST), 267(SA), 268(CO), 269(CO), 270(CO), 271(SU), 272(SA), 273(PO), 274(HY), 275(WW), 276(HW), 277(SU), 278(SU), 279(SA), 280(IR), 281(EM), 282(SU), 283(SA), 284(SU), 285(CP), 286(EM), 287(EM), 288(SA), 289(CO).

OCTOBER:[b] 290(all Divs), 291(ST)[a], 292(EM)[a], 293(ST)[a], 294(PO)[a], 295(HY)[a], 296(EM)[a], 297(HY)[a], 298(ST)[a], 299(EM)[a], 300(EM)[a], 301(SA)[a], 302(SA)[a], 303(SA)[a], 304(CO)[a], 305(SU)[a], 306(ST)[a], 307(SA)[a], 308(PO)[a], 309(SA)[a], 310(SA)[a], 311(SM)[a], 312(SA)[a], 313(ST)[a], 314(SA)[a], 315(SM)[a], 316(AT), 317(AT), 318(WW), 319(IR), 320(HW).

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a. Presented at the New York (N.Y.) Convention of the Society in October, 1953.
b. Beginning with "Proceedings-Separate No. 290," published in October, 1953, an automatic distribution of papers was inaugurated, as outlined in "Civil Engineering," June, 1953, page 66.
c. Discussion of several papers, grouped by Divisions.
d. Presented at the Atlanta (Ga.) Convention of the Society in February, 1954.
e. Presented at the Atlantic City (N.J.) Convention in June, 1954.

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